Agenda

• Graph Use Cases
• Open Source Graph Evolution
• Future Directions
Property Graph Model

- Vertices
- Edges
- Properties

Image: Graph of the Gods (CC-BY-4.0) https://janusgraph.org
Vertex

- **Vertices**
  - An entity in the graph
  - Has a unique identifier and a label
  - Can connect to other vertices with an edge
  - Can contain additional properties

- **Edges**

- **Properties**

```
id: 1024
label: god
name: jupiter
age: 5000
```

```
id: 1028
label: demigod
name: hercules
age: 30
```
• Vertices

• **Edges**
  • A directional relationship in the graph
    • Out-vertex (source) connects to in-vertex (target)
  • Has a unique identifier and a label
  • Can contain additional properties
  • Multiple edges are possible between the same 2 vertices
  • Navigate through edges in either direction

• Properties

**Diagram:**
- Node labeled "father" with id: 1028, label: god, name: jupiter, age: 5000
- Node labeled "heracles" with id: 1028, label: demigod, name: hercules, age: 30
Properties

- Vertices
- Edges
- Properties ←
  - Additional metadata for vertex or edge
  - Key-value pairs
  - Values can be singular or multiple

name: jupiter
age: 5000

name: hercules
age: 30
Personal Dashboard

BORSE, SANTOSH S (Santosh)
Developer - Watson Platform Services Watson

Overall 77 Your Score

Scores during the last 6 refresh cycles:
- 80
- 79
- 78
- 77
- 76

Scores updated on February 13, 2017

Activity
Collaborative activities done in Connections
66 Your score

Reaction
Feedback and response received from other employees
78 Your score

Eminence
Leadership and influence among the community
78 Your score

Network
Network size and diversity
84 Your score

New
Personal recommendations to help you raise your social engagement. Try it out!
Airline Routing

Image: Map by Kelvin Lawrence (ALv2)
https://github.com/krlawrence/graph
JanusGraph DATA BROWSER

1. \texttt{GraphTraversalSource g = ConfiguredGraphFactory.open("example").traversal();}
2. \texttt{g.V().has("CDI", "172CBAFEXV59").}
3. \texttt{repeat( outE("GENERATES").otherV() ).emit().until( outE("GENERATES").count().is(eq(0)) ).}
4. \texttt{path().toList();}
Where Do You See Graphs?

Image: Graph Globe (ALv2)
https://tinkerpop.apache.org
• Graph Use Cases

• Open Source Graph Evolution

• Future Directions
Graph Framework

- Apache TinkerPop
  - Vendor-neutral graph computing framework
  - Created in 2009 by Dr. Marko A. Rodriguez
  - [https://tinkerpop.apache.org](https://tinkerpop.apache.org)

- Vendor Implementations
  - Neo4j
  - Datastax Enterprise Graph
  - Microsoft Azure Cosmos DB
  - Amazon Neptune
Gremlin Traversals

• Traversal
  • A walk through the graph from one vertex to another along a connected edge

• Gremlin
  • Graph domain-specific language for traversals in TinkerPop-compliant systems
• Which projects did Marko’s colleagues create with others?

g.V().
has('name', 'marko').
out('knows').
outE('created').
has('weight', lt(1.0))
inV().
values('name')
• Which projects did Marko’s colleagues create with others?

g.V().
  has(‘name’, ‘marko’).
  out(‘knows’).
  outE(‘created’).
  has(‘weight’, lt(1.0)).
  inV().
  values(‘name’)

• “Select all vertices”

Image: TinkerPop Modern and Gremlin Running (ALv2)
https://tinkerpop.apache.org
Which projects did Marko’s colleagues create with others?

g.V().
  has('name', 'marko').
  out('knows').
  outE('created').
  has('weight', lt(1.0)).
  inV().
  values('name')

“Filter vertices where ‘name’ is Marko”

Global vertex scan

Image: TinkerPop Modern and Gremlin Running (ALv2)
https://tinkerpop.apache.org
• Which projects did Marko’s colleagues create with others?

```
g.V().
has('name', 'marko').
out('knows')
outE('created').
has('weight', lt(1.0))
inV().
values('name')
```

• “Utilize index on ‘name’ property”
• Leverage indexes for performance

Image: TinkerPop Modern and Gremlin Running (ALv2)
https://tinkerpop.apache.org
Which projects did Marko’s colleagues create with others?

```
g.V().
  has('name', 'marko').
  out('knows')
  outE('created').
  has('weight', lt(1.0))
  inV().
  values('name')
```

“Follow outward on ‘knows’ edges to adjacent vertices”

Image: TinkerPop Modern and Gremlin Running (ALv2)
https://tinkerpop.apache.org
• Which projects did Marko’s colleagues create with others?

g.V().
  has(‘name’, ‘marko’).
  out(‘knows’).
  outE(‘created’).
  has(‘weight’, lt(1.0))
  inV().
  values(‘name’)

• “Follow outward on ‘created’ edges”
Which projects did Marko’s colleagues create with others?

```
g.V().
  has('name', 'marko').
out('knows').
outE('created').
has('weight', lt(1.0))
inV().
values('name')
```

“Filter edges where ‘weight’ is less than 1.0”
Which projects did Marko’s colleagues create with others?

```
g.V()
  .has('name', 'marko')
  .out('knows')
  .outE('created')
  .has('weight', lt(1.0))
  .inV()
  .values('name')
```

“Follow inward to the target vertex”
• Which projects did Marko’s colleagues create with others?

```java
g.V()
  .has('name', 'marko').
  .out('knows').
  .outE('created').
  .has('weight', lt(1.0))
  .inV().
  .values('name')
```

• “Emit the value of ‘name’ property”

- lop
Graph Database

- Titan DB
  - Open source scalable graph database
  - Created by Dr. Matthias Broecheler
  - Acquired by Datastax in 2015
  - Titan 1.0 released
  - Community left hanging

Image: Traversal Strategy (ALv2)
https://tinkerpop.apache.org
Graph Database

- JanusGraph
  - Fork of Titan DB hosted at The Linux Foundation
  - Reconnect open source community
  - Embrace open governance
  - https://janusgraph.org

- Diverse Community
  - Founders: Expero, Google, Grakn, Hortonworks, IBM
  - Comcast, Goldman Sachs, Netflix, Uber, VMWare, and many others
• Apache Atlas
  • Metadata management for governance
• Egeria (ODPi, Linux Foundation)
  • Open metadata and governance
• Eclipse Keti
  • Access control service to protect RESTful APIs
• Exakat
  • PHP static analysis
• Open Network Automation Platform (Linux Foundation)
  • Automation and orchestration for software-defined networks
• Windup by Redhat
  • Application migration and assessment
Key Benefits

- Apache-licensed open source
  - Permissive software licensing
  - Free to use anywhere

- Open governance community
  - No single vendor control or lock-in
  - Open collaboration and development

- Pluggable storage and indexing
  - Leverage existing technology and skills
  - Compare performance characteristics
Open Source at IBM

IBM's home for open source code, community, and culture

For the past 20 years, IBM has invested significantly in open source code, communities, and governance. Learn where we partner, how you can join us, and how you can create an open enterprise.

- Code Patterns

- JanusGraph Utilities
  - https://github.com/IBM/janusgraph-utils

- Getting Started blog series

- Tips and Tricks blog series
• Graph Use Cases

• Open Source Graph Evolution

• Future Directions ←
Project Directions

- Diversify client driver support
  - .NET
  - Python
  - Javascript

- Platform support
  - Windows
  - Docker
  - Apache Ambari

- Administration Console
- Operations tooling, monitoring

- Diversify backend storage support
  - In-memory
  - FoundationDB
  - Couchbase

- Benchmarking
- ETL, bulkloading, serialization
- Query profiling, traversal optimization

- Apache TinkerPop 4
- Property Graph Schema Working Group
Thank You!

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Apache TinkerPop | JanusGraph